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Sustainability of Pelagic Fisheries Resources in Tomini Gulf, Northern Sulawesi, Indonesia

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Abstract: Research on sustainability analysis has been carried out in the waters of the Tomini Gulf, which covers nine district/cities coast, The objective of this paper is to analyse the sustainability status of pelagic fisheries resources. The Raps-Tomini approach was used in this study where primary data was gathered from in-depth interviews with 86 informants consisting of 75 fishermen and 11 officials from the Indonesian Department of Fisheries and Marine. Results indicated that the ethics, laws and regulations do not support the sustainability of pelagic fishery resources in the waters of the Tomini Gulf, especially on restrictions on access to fishing attributes. Without any restrictions on fishing access will cause the fishermen to catch fish all the time, threatening the sustainability of the fish resource. Aspects of ethics, law and government regulations require attention for sustainability pelagic fishery resources Gulf of Tomini be guaranteed.

Key words: Pelagic fish · Marine Sustainability · Ethics · Raps-Tomini

INTRODUCTION

Tomini Gulf waters have fish resources which are large enough to support the region's economy. Several economically important fish species found in this region; commodity mainstay of this region include fish malalugis (*Decapterus macarellus*), yellow fin tuna (*Thunnus albacares*), skipjack (*Katsuwonus pelamis*) and several types of reef fish. The results note that Tomini Gulf waters, the Molucca Sea and Seram Sea pelagic fish resource potential around 486,000 tonnes per year of which 80% are in the form of small pelagic fish [1]. Further, it is reported that the level of exploitation of small pelagic has reached more than 50% and large pelagic reached 21%. Alleged exploitation has not had a profound effect on the rate of arrests and biological resources. Exploitation rates of pelagic fish in Tomini Gulf was low allow to be developed. Number of fishing households was recorded in North Sulawesi, Gorontalo and Central Sulawesi as many as 51,684 [1]. The fishery potential of Tomini Gulf region was 590,620 tonnes per year but the utilization rate of 197,640 tonnes per year (33.46%) [2]. As for the large pelagic fishery potential of 39,420 tonnes per year and the rate of use was 37.01%. The results research in the waters of the District Parigi Moutong (Tomini Gulf) showed that the optimum unit attempts to capture the tuna purse seine by 10,813 trips per year, the fish kite for 7,840 trips per year and mackerel for 8,129 trips per year while purse seine fishing effort is currently at 5,005. trip so it is possible to increase arrests trip [3]. The results showed that the level of exploitation of pelagic fishery resources Tomini Gulf still under fishing

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[4]. Pelagic fishery resource potential still thought it necessary underfishing for sustainable management. This fishery has been included recently in a certification program of sustainable fishing [5]. Model estimates of total catches suggest substantial misreporting in some years, though the precision of the estimates is very low [6]. An ecosystem approach for management can be made operational through a progressive evolution of traditional fisheries management that extends strategies beyond consideration of productivity for only the harvested resources to productivity, biodiversity and habitat of the ecosystem and then integrates the cumulative effects across managed human activities [7]. Today, with co-management widely embraced by the research community and adopted as policy by an increasing number of governments, a second-generation perspective has emerged [8]. The great emphasis placed on the democratic participation of local user groups as necessary for sustainable natural resource and environmental governance by scholars, advocates and practitioners of collaborative natural resource management demands a greater focus on who is and who is not participating in governance processes, why and the potential consequences [9]. The purpose of this paper were analyze the sustainability status of pelagic fisheries resources of Tomini Gulf.

METHODS AND MATERIALS

Sustainability analysis in this study using the *Raps-Tomini* (Rapid appraisal for pelagic resource of Tomini) which is a modification of the method Rapfish (Rapid appraisal for fisheries) is a method for evaluating the sustainability status of fisheries management developed by the multidisciplinary Fisheries Centre, University of British Columbia, Vancouver, Canada [10]. This method has used for a total of 17 fishery systems covering gillnets, traps and seines targeting fish and crustaceans as well as hand-collected mussels in the state of Pernambuco (Brazil) were compared and analyzed in the present study using the RAPFISH method and 57 attributes to qualify five evaluation dimensions: economic, social, ecological, technological and management [11]. Likewise [12] using the Rapfish method – a rapid, innovative assessment model of fishery sustainability consisting of a multivariate ordination analysis of ecological, technological, social and economic data. The fisheries were divided into 26 fishery systems according to type of fleet, gear, target resource, ecosystem and environmental characteristics. *Raps-Tomini* ordination technique based on the use of Multi-Dimensional-Scaling (MDS). MDS is a statistical technique that tries to transform into a multi-dimensional lower dimension.

Raps-Tomini analysis begins by reviewing and defining attributes fisheries will be analyzed, in this case based on the fishing gear used to catch pelagic fish such as: seine nets, purse seine, gill nets, lift nets and hook and lines. Then do the scoring is based on a review of the attributes that have been specified. MDS then performed to determine the relative position against the ordination of fisheries good and bad. MDS ordination technique based on the euclidean distance in n-dimensional space is written as follows:

$$D = \sqrt{\left(\left|x_1 - x_2\right|^2 + \left|y_1 - y_2\right|^2 + \left|z_1 - z_2\right|^2 + ...\right)} \quad (1)$$

Configuration of an object or point in MDS then approximated by regressing euclidian distance (d_{ij}) from point i to j with the point of origin (d_{ij}) as the following equation:

$$d_{ij} = a + bd_{ij} + e \quad (2)$$

There are three ways that can be used for regressing equation (2), namely: least square method, least square turned method is based on the alternate root of euclidian distance (squared distance) or called ALSCAL method and a method based on maximum likelihood. The three methods is the most appropriate method for ALSCAL [12]. ALSCAL method can optimize squared distance (squared distance = d_{ijk}) squares to the data origin (O_{ijk}) are in a three-dimensional formula written in the so-called S-Stress as follows:

$$S = \sqrt{\frac{1}{m}\sum_{k=1}^{m}\left[\frac{\sum_i\sum_j (d_{ijk}^2 - o_{ijk}^2)^2}{\sum_i\sum_j o_{ijk}^2}\right]} \quad (3)$$

where the squared distance is a weighted euclidian distance, is written:

$$d_{ijk}^2 = \sum_{a=1}^{r} w_{ka}\left(x_{ia} - x_{ja}\right)^2$$

At each measurement is metric, a condition fit (goodness of fit), the point estimate of the distance to the point of origin is very important. Goodness of fit in MDS is nothing but the measure of how precise configuration of a point to reflect the original data. Goodness of fit in MDS reflected on the value of the

s-stress. In *Raps-Tomini*, a good model is shown with the s-stress value smaller than 0.25. Sustainability analysis of pelagic fishery resources in Tomini Gulf based on fishing gear used to catch pelagic fish such as: seine nets, purse seine, gill nets, lift nets and hook and lines. In this sustainability analysis techniques used *Raps-Tomini* with five dimensions namely: ecology, economy, social, technology and ethic, law and regulation [13].

Table 1: List of dimensions and attributes for sustainability analysis Ecology dimension

Attribute	Note	Good	Bad
Level of exploitation	Score : (0) far below the potential for sustainable; (1) approaching potential for sustainable; (2) same with the potential for sustainable; (3) over exploitation ; (4) approaching collapse	0	4
Recruitment variability	Score : COV : (0) low (< 40%); (1) medium (40-100%); (2) high (>100%).	0	2
Changes in trophic level	Score : (0) unchange ; (1) little changed; (2) a lot has changed.	0	2
Migratory range	Score : The fish migration past district boundary waters (0) 1-2 district; (1) 3-4 districts (2)> 4 districts	0	2
Range collapse	Score : symptoms decreased catches. (0) no; (1) there is little; (2) no symptoms of decline that is easy to read; (3) there is a very obvious symptom reduction.	0	3
Size of fish caught	Score: (0) did not change; (1) change slowly; (2) changes rapidly.	0	2
Catch before maturity	Score: percentage of immature fish (0) <30%; (1) 30-60%; (2)> 60%.	0	2
Discarded bycatch	Score: the percentage of non-target fish were caught. (0) 0-10%; (1) 10-40%; (2)> 40%	0	2
Species caught	Score: number of fish species caught. (0) 1-10 species; (1) 10-100 species, (2) > 100 species	0	2
Primary production	Score: (in g C/m2/tahun). (0) Low (0-50); (1) medium (50-90); (2) high (90-160); (3) very high > 160.	3	0
	Economy dimension		
Attribute	Note	Good	Bad
Profitability	Score: (0) very profitable (RC> 2.5); (1) benefit (1 <R / C <2.5); (2) BEP (R = C); (3) loss (R <C); (4) huge loss (R << C).	0	4
Contribution of the fisheries sector GDP	Score: (0) low; (1) medium; (2) high.	2	0
Income relative to the minimum wage	Score: (0) much lower; (1) slightly lower; (2) approximately equal; (3) slightly higher; (4) much higher.	4	0
Profit sharing	Score: (0) never; (1) rarely, (2) sometimes; (3) often; (4) always.	4	0
Cooperative fishery	Score: (0) not closely; (1) close; (2) very closely.	2	0
Other income	Score : fishing is mainly: (0) casual; (1) part-time; (2) seasonal; (3) full-time	0	3
Sector employment	Score : (0) <10%; (1) 10-20% ; (2) >20%	0	2
Benefits of fisheries activities	Score: benefits enjoyed by fishing activities: (0) local communities; (1) mix; (2) outside the area.	0	2
Market	Score: main market (0) local/national; (1) national/ regional; (2) international	0	2
Subsidy	Score: subsidies, (0) no, (1) a little (2) large, (3) dependent, (4) highly dependent.	0	4
	Social dimension		
Attribute	Note	Good	Bad
Social relations	Score: (0) Fishermen working as an individual; (1) working with family; (2) work in groups (cooperatives/ companies).	2	0
New entrants into the fishery	Score: growth in the last 5 years, (0) <10%; (1) 10-20%; (2) 20-30%; (3) > 30%.	0	3
The number of fishing household	Score : (0) < 1/3; (1) 1/3-2/3); (2) > 2/3	0	2
Environmental knowledge	Score: not knowing; (1) little knowing; (2) many knowing.	2	0
Education level	Score: level of education than the average population. (0) is lower; (1); same; (2) above.	2	0
Conflict between fishermen	Score: (0) did not happen; (1) sometimes occurs; (2) often occur.	0	2
participation level of fishermen	Score: levels of participation, (0) low; (1) medium; (2) high.	2	0
Portion of the family income	Score: income from fisheries, (0) <50%; (1) 50-80%; (2)> 80%.	2	0
The involvement of family members	Score: A family member is involved, (0) no; (1) 1-2 people; (2) 3-5 people; (3) 6-8 people; (4) > 8.	4	0
	Technology dimension		
Attribute	Note	Good	Bad
Trip length	Score: (0) ≤ 1 day; (1) 2-4 days, (2) 5-8 days, (3) 8-10 days, (4)> 10 days.	0	4
Lending site	Score: (0) spread > 3 places; (1) 3 place; (2) 1-2 place; (3) there is no landing place (including sales in the middle of the sea)	0	3
Pre-sale processing	Score: (0) untreated; (1) partially processed, (2) entirely processed.	2	0
Handling on board	Score: (0) no treatment; (1) salting / boiling, (2) cooling / freezing, (3) handling life.	3	0
Fishing gear	Score: (0) passive; (1) active.	0	1
Selectivity of fishing gear	Score: (0) less selective; (1) quite selective; (2) highly selective	2	0
Fish aggregating devices	Score: (0) no use; (0.5) using bait; (1) using tools (for example: lights and / or FADs).	0	1
Vessel size	Score: length of the vessel, (0) <5m; (1) 5 - 10m; (2) 10-15m; (3) 15-20m (4)> 20m	0	4
Catching power	Score: changes in the ship's engine capacity last 5 years, (0) no; (1) a little; (2) medium; (3) rather large; (4) large.	0	4
Gear side effects	Score: (0) never use: (1) rarely use, (2) sometimes use, (3) always use.	0	3

Table 1: Continued

Ethic, law and regulation dimension			
Attribute	Note	Good	Bad
Law enforcement	Score: (0) never, (1) rarely, (2) often, (4) always	3	0
The availability of other employment	Score: (0) no, (1) there are a few, (2) a lot.	2	0
The availability of formal rules of management	Score: (0) not available: (1) reasonably available, (2) widely available.	2	0
Involvement in decision making	Score: (0) is fully implemented by the government without consultation with the community; (1) conducted by the government and the public to be consulted, (2) conducted jointly led by the government, (3) conducted jointly led by community leaders, (4) conducted jointly with role and position are balanced.	4	0
Traditions/Beliefs	Score: (0) very negative; (1) negative, (2) does not affect anything, (3) positive, (4) very positive.	4	0
Restrictions on access to fishing	Score: (0) open access, no restrictions; (1) large, (2) medium, (3) small, (4) is closed.	4	0
Ecosystem management	Score: (0) did not either: (1) poor, (2) is quite good, (3) good, (4) very good.	4	0
The intensity of violation of law	Score: (0) no / never; (1) sometimes, (2) often.	0	2
Discards and wastes	Score: (0) no / little; (1) medium, (2) a lot.	0	2

Ecology dimension consist of ten attributes, namely : level of exploitation, recruitment variability, changes in trophic level, migratory range, range collapse, size of fish caught, catch before maturity, discarded bycatch, species caught and primary production. Economy dimension consists ten attributes, namely: profitability, contribution of the fisheries sector GDP, income relative to the minimum wage, profit sharing, cooperative fishery, other income, the involvement of family members, benefits of fisheries activities, market and subsidy. Social dimension consists of nine attributes, namely: social relations, new entrants into the fishery, the number of fishing household, environmental knowledge, education level, conflict between fishermen, the level of participation of fishermen, portion of the family income and the involvement of family members. Technology dimension consists of ten attributes, namely: trip length, lending site, pre-sale processing, handling on board, fishing gear, selectivity of fishing gear Fish aggregating devices, vessel size; catching power and Gear side effects. Dimension of ethic, law and regulation consist of nine attributes namely: law enforcement, the availability of other employment, the availability of formal rules of management, Involvement in decision making, traditions/beliefs, restrictions on access to fishing, ecosystem management, the intensity of violation of law discards and wastes. List of dimensions and attributes showed Table 1.

RESULTS AND DISCUSSION

Sustainability analysis of pelagic fishery resources in Tomini Gulf based on fishing gear used to catch pelagic fish such as: seine nets, purse seine, gill nets, lift nets and hook and lines. In this sustainability analysis techniques used *Raps-Tomini* analyzes with five dimensions: ecology, economic, social, technology and ethical, legal and regulatory.

Ecology Dimension: Results of leverage analysis of ecological dimensions are as follows : level of exploitation = 1.42; recruitment variability = 1.98; changes in trophic level = 2.20; migratory range = 2.41; range collapse = 4.12; size of fish caught = 2.32; catch before maturity = 2.16; discarded bycatch = 1.75; species caught = 1.33 and primary production = 3.02. Attribute the range collapse and primary production generate leverage values ??respectively of 4.12 and 3.02 are the two biggest values ??of the attributes analyzed. This means that both of these attributes is an indicator of the sustainability of pelagic fishery resources that need attention. Fishers' ecological knowledge provides an alternate path from which to more fully understand fishery health and trends, thereby establishing the foundation from which locally appropriate and supported fishery management can form [14].

Economy Dimension: Results of leverage analysis of economic dimensions are as follows: profitability = 2.21; contribution of the fisheries sector GDP = 3.53; income relative to the minimum wage = 3.06; profit sharing = 1.82; cooperative fishery = 3.86; other income = 6.07; the involvement of family members = 3.82; benefits of fisheries activities = 3.99; market = 3.68 and subsidy =2.85. results of leverage analysis indicate that attributes other income has the highest value compared with other attributes which is equal to 6.07. This suggests that in addition to the income of fishermen from fishing effort

greatly affect the sustainability of pelagic fishery resources. Therefore acceptance of primary fisheries management as a final and sufficient goal could therefore add a further constraint on the possibility of fishing communities escaping the poverty trap [15]. Increase family income needs attention. The top five most frequently measured outcome indicators are access to resources, resource well-being, fishery yield, household well-being and household income [16].

Social Dimension: Results of leverage analysis of social dimensions are as follows: social relations = 1.49; new entrants into the fishery = 3.48; the number of fishing household = 5.35; environmental knowledge = 6.65; education level = 8.14; conflict between fishermen = 5.63 the level of participation of fishermen = 5.65; portion of the family income = 3.86 and the involvement of family members =1.68. Results of the analysis indicate that leverage social dimension attribute has the highest level of education compared to other attributes which is equal to 8.14. This means that the education level of fishermen greatly affect the sustainability of pelagic fishery resources in Tomini Gulf.

Technology Dimension: Results of leverage analysis of technological dimensions are as follows: trip length =0.90; lending site = 1.92; pre-sale processing = 5.64; handling on board = 4.36; fishing gear = 5.46; selectivity of fishing gear = 5.63; fish aggregating devices = 4.49; vessel size = 2.22; catching power = 3.04 and gear side effects = 1.78. Leverage the results of the analysis indicate that the technological dimension attribute processing prior to the sale have the highest leverage the value of 5.64. Attribute processing prior to sale is a concern because most of the catches of pelagic fish in Tomini Gulf sold in fresh form without processing both to collectors and to the fish processing plant. Fishermen did not do its own processing so that the economic value of their catch is not enjoyed.

Ethic, Law and Regulation Dimension: Results of leverage analysis of ethic, law and reglation dimensions are as follows: law enforcement = 2.32; the availability of other employment = 1.95; the availability of formal rules of management = 2.05; involvement in decision making = 2.52; traditions/beliefs = 1.49; restrictions on access to fishing = 3.66; ecosystem management = 1.91; the intensity of violation of law = 2.99; discards and wastes = 1.45. Results of analysis leverage broader ethical, law and regulation restrictions on access attribute indicates that the capture has the highest leverage the value of which is equal to 3.66. This means that it is a very important attribute to consider in order to ensure the sustainability of pelagic fishery resources in Tomini Gulf. Access restricted arrests can be done by limiting the input and output restrictions. Input restrictions are restrictions on the amount of equipment and the trip was catching while output restriction in the number of catches. Concluded by [17] that ethical fisheries are also sustainable and highlight emerging environmental laws and collaborative governance approaches that may help achieve both goals.

In terms of the ecological dimensions of seine nets, purse seine, gill nets and hook and lines were good categories in supporting the sustainability of pelagic fishery resources while lift nets including enough category. S-Stress values ??reflect the goodness of fit in the analysis of the Multi Dimensional Scaling (MDS) which shows a measure of how precise configuration of a point to reflect the original data. In the analysis of the Multi Dimensional Scaling (MDS) are a good stress value of less than 25% [18]. Strss value ecological dimensions of 14.98% indicates that the goodness of fit because the stress value obtained is less than 25%. Judging from the economic dimensions of seine nets, purse seine, gill nets, lift nets and hook and lines include enough categories to support the sustainability of pelagic fishery resources in the waters of Tomini Gulf. Squared correlation (R^2) the economic dimension of 94.99% indicates that there is a strong link between the economic dimension of sustainability of fishery resources in the waters of Tomini Gulf. Stress values ??reflect the goodness of fit in the analysis of the Multi Dimensional Scaling (MDS) which shows a measure of how precise configuration of a point to reflect the original data. In the analysis of the Multi Dimensional Scaling (MDS) are a good stress value of less than 25% [18]. Strss value economic dimension of 14.10% indicates that the goodness of fit because the stress value obtained is less than 25%. In terms of the social dimensions ofseine nets, purse seine, gill nets, lift nets and hook and lines include enough categories to support the sustainability of pelagic fishery resources in the waters of Tomini Gulf. Squared correlation (R^2) social dimensions of 89.84% indicates that there is a strong link between social dimension to the sustainability of fishery resources. Stress values ??reflect the goodness of fit in the analysis of the Multi Dimensional Scaling (MDS) which shows a measure of how precise configuration of a point to reflect the original data. In the analysis of the Multi Dimensional Scaling (MDS) are a good stress value

Table 2: Matrix Pelagic Fishery Resource Sustainability Levels in Gulf waters Tomini

No	Dimension	Fishing Gear				
		Seine nets	Purse seine	Gill nets	Lift nets	Hook and lines
1	Ecology (10 Attribute)					
	R^2	95.71%	95.71%	95.71%	95.71%	95.71%
	S-Stress	14.98%	14.98%	14.98%	14.98%	14.98%
	Ordination	86.50	86.60	81.03	65.33	95.39
	Sustainability	good	good	good	enough	good
2	Economy (10 Attribute)					
	R^2	94.99%	94.99%	94.99%	94.99%	94.99%
	S-Stress	14.10%	14.10%	14.10%	14.10%	14.10%
	Ordination	58.96	68.96	53.67	53.07	62.85
	Sustainability	enough	enough	enough	enough	enough
3	Social (9 Attribute)					
	R^2	89.84%	89.84%	89.84%	89.84%	89.84%
	S-Stress	15.88%	15.88%	15.88%	15.88%	15.88%
	Ordination	63.96	65.75	63.13	57.32	56.45
	Sustainability	enough	enough	enough	enough	enough
4	Teknology (10 Attribute)					
	R^2	93.12%	93.12%	93.12%	93.12%	93.12%
	S-Stress	13.46%	13.46%	13.46%	13.46%	13.46%
	Ordination	45.19	42.80	77.60	43.77	81.91
	Sustainability	less	less	good	less	good
5	Ethics, Law and Regulation (9 Attribute)					
	R^2	94.55%	94.55%	94.55%	94.55%	94.55%
	S-Stress	16.62%	16.62%	16.62%	16.62%	16.62%
	Ordination	39.65	39.65	36.52	30.29	36.51
	Sustainability	less	less	less	less	less

of less than 25% [18]. Strss value of the social dimension of 15.88% indicates that the goodness of fit because the stress value obtained is less than 25%. Judging from the technological dimension of seine nets, purse seine and lift nets unfavorable category sustainability while gill nets fishing gear and fishing rods including both categories. Squared correlation (R^2) technology dimensions of 93.12% indicates that there is a strong link between the technological dimension of sustainability of fisheries resources in the waters of the Gulf of Tomini. Stress values ??reflect the goodness of fit in the analysis of the Multi Dimensional Scaling (MDS) which shows a measure of how precise configuration of a point to reflect the original data. In the analysis of the Multi Dimensional Scaling (MDS) are a good stress value of less than 25%[18]. Strss value technological dimension of 13.46% indicates that the goodness of fit because the stress value obtained is less than 25%. Judging from the dimensions of ethics, law and regulation, it trawl gear bag, purse seine, gill nets, lift nets and fishing line category lacking in supporting the sustainability of pelagic fishery resources in the waters of the Gulf of Tomini. Squared correlation (R^2) dimension of ethics, laws and regulations of 94.55% indicates that there is a strong link between the dimensions of ethics, laws and regulations to the sustainability of fishery resources in the waters of the Gulf of Tomini. Stress values reflect the goodness of fit in the analysis of the Multi Dimensional Scaling (MDS) which shows a measure of how precise configuration of a point to reflect the original data. In the analysis of the Multi Dimensional Scaling (MDS) are a good stress value of less than 25% [18] Strss value dimension of ethics, laws and regulations of 16.62% indicates that the goodness of fit because the stress value obtained is less than 25%. Summary matrix level of sustainability of pelagic fishery resources in Tomini Gulf based on the dimensions and gear are presented in Table 2.

CONCLUSION

Dimensions of ethics, laws and regulations do not support the sustainability of pelagic fishery resources in the waters of the Gulf of Tomini. Aspects of ethics, laws and regulations, particularly on access restriction attributes unlawful arrest and intensity need to get the government's attention for sustainability pelagic fishery resources in the waters of the Gulf of Tomini be guaranteed.

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